

AN OPTICAL DATA LINK FOR REMOTE COMPUTER TERMINALS

foiling
the phone company

by Jack R. Baird

The increased usage of remote terminals for large computers has created a demand for a short range, medium bandwidth communication system or data link. A laser communication system¹ can easily accomplish this objective but the cost of such a system is usually prohibitive.

The object of this article is to describe an optical data link which is in use at the University of Colorado, Boulder, which is both highly reliable and extremely economical.

The system has been in continuous operation for over two months and in that time has required absolutely no maintenance and has provided reliable communication over the one kilometer path length through both heavy rain and fog. The only observed failure of the system was during a heavy snow storm when 13 inches of snow fell and visibility was reduced to a few hundred feet at times.

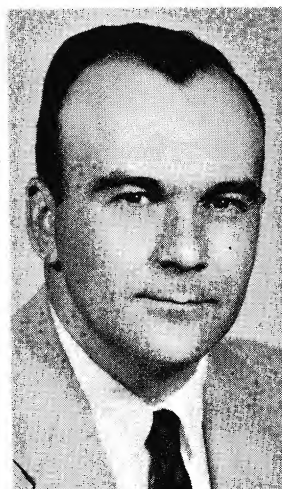
The basic transmitter element is a gallium-arsenide infrared light emitter costing approximately \$15 and the basic element of the receiver is a \$9 phototransistor. The most expensive components in the communications link are the condensing lenses which are five inches in diameter and cost \$40 each.

The entire system is illustrated in the block diagram of Fig. 1. The main computer is a Control Data Corp. Model 6400 with a normal complement of local terminal equipment. The main computer is interfaced to the General Electric Data Set through a CDC-6673 Data Set Controller.

The remote terminal is a CDC Model 8231 terminal using one 1200 cpm card reader, a typewriter, and one 1000 lpm line printer. The system is operated in a half-duplex mode but the data link itself is capable of full duplex operation. The 40.8 kilobit data rate is sufficiently high that a second 1000 lpm line printer can be added to the remote terminal.

This is a completely normal high speed remote terminal system with the exception of the manner in which the two GE Data Sets are interconnected. In a normal installation

the data sets are interconnected by two "baseband grade" telephone lines. Ordinary "voice grade" telephone lines are not sufficient because the bandwidth on such lines is less than 4 kilohertz. A baseband grade line has a usable bandwidth of 50 kilohertz and normally could be used by the phone company to carry 12 individual phone lines. Most installations require two baseband lines from the main computer to the telephone switchboard where they bypass the switchboard and are permanently connected to two other baseband lines from the switchboard to the remote terminal. Such an installation would consume line capacity which could normally be used to provide service to 48 individual business phones; thus it is not surprising that the cost for such service is approximately 48 times the rate for an individual business phone. Rates will vary considerably from one installation to the next, but a cost in excess of



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¹ Ross, *Laser Receivers*, 1966, Wiley & Sons.

\$5000 per year is quite common.

In the system described here, the telephone lines have been replaced by a two-way optical data link at a considerable savings in installation and operating cost. In this system the path length between transmitter and receiver is approximately one kilometer and a direct line of sight is obtainable from the tops of the two buildings housing the computer and the remote terminal. At least 300 feet of

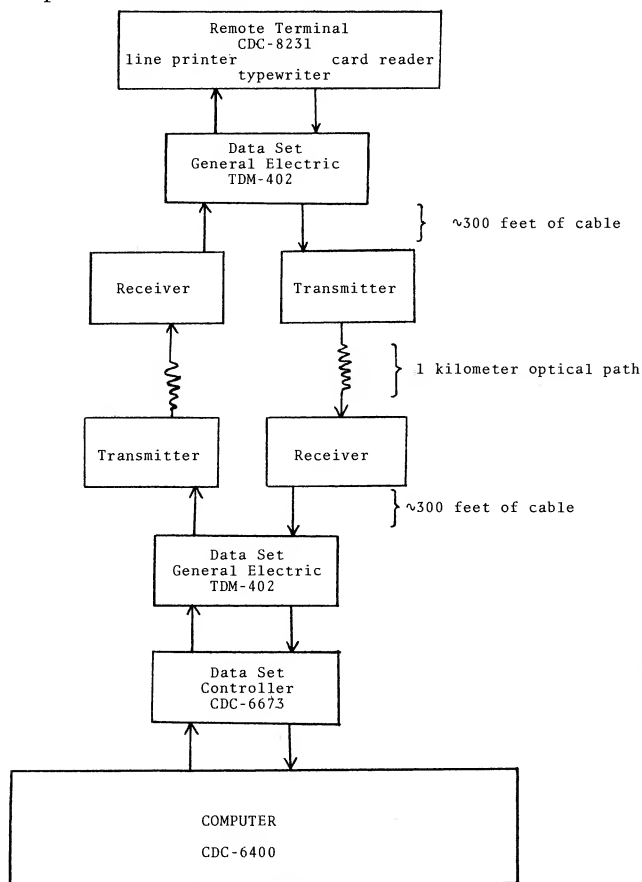


Fig. 1. Block diagram of the system.

cable is used between the data sets and the optical transmitter-receiver installations. A considerably longer cable could be used without serious problems.

A photograph of one of the two transmitter-receiver installations is shown in Fig. 2. Both units are completely within the building and the infrared signals are transmitted through ordinary window glass. Each of the two six-inch-diameter tubes is used to support the focusing lenses, each of which is 146 millimeters in diameter with a focal length of 410 millimeters.

The transmitting element, located near the focal point of the transmitting lens, is a GE infrared solid state lamp Type SSL-5C. This lamp is a gallium-arsenide light-emitting junction mounted in a TO-18 transistor case with a glass lens in the top. The diode has a rated continuous wave power output of seven milliwatts in a 300 angstrom bandwidth centered at about 9400 angstroms. The radiation pattern of the SSL-5C has a half power beam width of approximately 18° total angle. Typically, there is but 1 to 2 milliwatts of power within this beam width, the remaining power being in side lobes and skirts outside of the main beam.

The input to the light emitter is 500 milliamps at 1.8 volts and is easily controlled and modulated by a two-stage transistor amplifier operating from a 10 volt power supply.

The receiving element, located near the focal point of the receiving lens, is a Motorola phototransistor Type MRD300. This is a silicon transistor also mounted in a TO-18 transistor case with a glass lens on top. The receiving amplifier consists of some eight transistors and one integrated circuit. The amplifier contains automatic gain control to provide a constant output signal voltage while the input voltage varies over a range of 100 to 1. This wide range of AGC is to compensate for the variations in the path loss due to adverse weather conditions. Additional AGC is available in the GE data sets but it is not used in this installation. There were several other minor modifications made in the data sets to make them compatible with this system.

range and bandwidth

At the present time it is difficult to predict the maximum range and maximum bandwidth of such a system. The ultimate range or bandwidth of such a system will likely not be limited by transmitter power or receiver sensitivity but instead will be limited by the AGC range which can be incorporated into the receiver amplifier. The best informa-

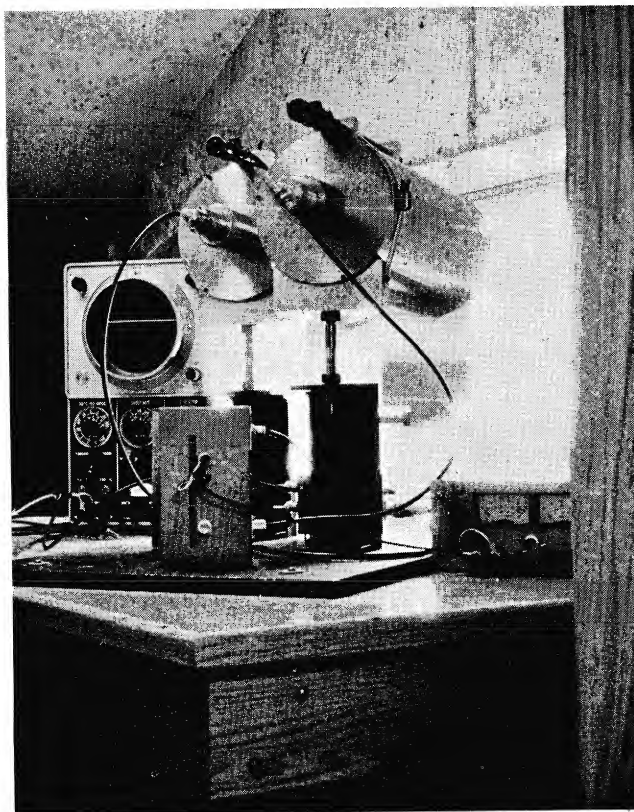


Fig. 2. One of the two transmitter-receiver stations.

tion available today indicates that the received power can be expected to fluctuate by more than 20 db for every kilometer of path length. With present technology, it would appear that a 2 kilometer path length may be the maximum range for reliable communications. However, repeater stations are very economical and could be used to considerably extend the range.

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